TITLE OF THE INVENTION
RETICLE FABRICATION METHOD

Field of the Invention

5   The present invention relates to a method of
fabricating masks for a photolithography process performed
on a reticle or the like which is used in fabricating a
semiconductor integrated circuit device.

Description of the Related Art

10   In the photolithography process that is essential in
the fabrication process for a semiconductor integrated
circuit device, generally, a mask called a reticle which is
acquired by writing the design pattern of a desired
semiconductor integrated circuit on a light transmittive

15   substrate, such as a quartz glass substrate, with a light
shielding material such as chromium (Cr) is used as a master
plate. The present photolithography technology generally
employs a scheme of transferring a circuit pattern written
on the reticle onto a semiconductor wafer with a photoresist

20   applied thereto by reduction exposure by a factor of 4 to a
factor of 5.

     The microfabrication technology for semiconductor
integrated circuits demands microfabrication achieved at a
speed faster than is specified in the technology road map

25   made by the SIA (Semiconductor Industry Association). The
rapid advancement of the microfabrication technology
shortened the wavelengths of light sources to be used at the

time of exposing a circuit pattern written on a reticle onto a semiconductor wafer and progressed the developments of the light sources to various types, such as g rays, i rays, KrF and ArF. The photolithography technology that uses short-wavelength light sources, such as the KrF and ArF, employs super resolution techniques, such as OPC (Optical Proximity Correction) and phase shifting, for the purpose of acquiring a sufficient resolution which matches a micro circuit pattern. In this respect, circuit patterns to be written on reticles become extremely complex as well as become microfabricated more finely.

The amount of data that is handled at the time of writing a circuit pattern on a reticle becomes very huge due to the microfabrication and complexity of circuit patterns to be written on reticles. This leads to significant increases in the time and cost needed to fabricate reticles. For further microfabrication of circuit patterns, developments on photolithography technologies using VUV (Vacuum UltraViolet-ray) and EUV (Extreme UltraViolet-ray) have been set forward already but for the fear of the limitation to the light-based photolithography technology, there is a demand for earlier developments on photolithography technologies using X rays and an electron beam (EB). It is therefore expected that increases in the time and cost needed to fabricate reticles become more

prominent.

Fig. 1 is a flowchart illustrating a conventional reticle fabrication method. CAD (Computer Aided Design) data 101 such as the design pattern of a semiconductor integrated circuit is converted to an electron beam (EB) write data 103 by a first data conversion device 102. The EB write data 103 is input to an EB writing device 104 which writes a figure pattern such as a circuit pattern on an unwritten reticle 105 based on the input EB write data 103 to thereby yield a written reticle 106. The written reticle 106 is developed to be a developed reticle 107 which is inspected in a reticle inspection device 110 to check if the reticle 107 includes a pattern which is the CAD data 101 correctly transferred. Meanwhile, the CAD data 101 is converted to inspection data 109 in a second data conversion device 108. The inspection data 109 is input to the reticle inspection device 110 and is used to check if there is an error in the figure pattern written on the developed reticle 107. If it is verified through the inspection that the figure pattern is formed on the developed reticle 107 correctly, the developed reticle 107 is discriminated as good and becomes an inspected reticle 111.

In the conventional reticle fabrication method, the EB write data 103 that has been generated through data conversion in the first data conversion device 102 is input

to the EB writing device 104 without undergoing an inspection process and the figure pattern is written on the unwritten reticle 105. Even in case where a data conversion error has occurred, generating an erroneous EB write data 103, in the first data conversion device 102, therefore, the data conversion error cannot be detected in the EB writing device 104 before writing the figure pattern on the unwritten reticle 105. Even in case where a defect on the developed reticle 107 is detected in the inspection process in the reticle inspection device 110, it is extremely difficult to determine whether the defect is originated from a conversion error occurred in the first data conversion device 102 or occurred in the second data conversion device 108, or to determine whether the defect is a fabrication defect generated in the writing process or in the developing process. The reticle inspection device 110 detects if thee is a defect in the figure pattern formed on the developed reticle 107 by comparing a to-be-inspected image acquired from the figure pattern formed on the developed reticle 107 with a reference image generated from the inspection data 109. When a mismatch between the to-be-inspected image and the reference image is detected, therefore, it is necessary to start with the work of checking if the EB write data 103 contains a data conversion error in order to find a cause for the mismatch. In case where a data conversion error is

detected, it is necessary to correct the data conversion in the first data conversion device 102 and regenerate the EB write data 103. This makes the read time for fabrication of a reticle considerably longer.

5   Japanese Patent Laid-Open No. 252044/1992 discloses a method which is designed for the purpose of shortening the time needed for reticle fabrication and detects a reflection signal of an electron beam, irradiated on a quartz glass substrate, from the substrate's surface when writing a

10   circuit pattern on a quartz glass substrate to be reticle so as to ensure simultaneous execution of EB writing and a surface inspection of the adhesion of a foreign matter or the like and an inspection of a pattern data for a pattern defect or the like at the time of writing the circuit

15   pattern on the quartz glass substrate to be reticle. The prior art can detect if there is a defect in a pattern to be formed on a reticle at the time of carrying out EB writing. It is therefore possible to detect if there is a defect in a pattern on a written reticle at the early stage of the

20   fabrication flow, thus ensuring simplification and shortening of the subsequent inspection process. This suppresses a wasteful operation of the expensive reticle inspection device which should face with an issue of the effective availability factor.

25   While the prior art can detect a defect at the time of

writing a circuit pattern on a reticle, however, it cannot specify the cause for a defect, if detected. To find out the cause for a detected defect, therefore, the prior art, like the other prior arts, should verify if EB write data contains a data conversion error. Further, the fabrication cost would be increased significantly if the EB writing device which, like the reticle inspection device, is expensive and should face with an issue of the effective availability factor is operated to write a circuit pattern on a reticle based on EB write data containing a data conversion error. Furthermore, the reticle that is fabricated based on such erroneous EB write data would be wasted.

Japanese Patent Laid-Open No. 265192/1993 discloses a reticle fabrication method which verifies fabrication data for writing a pattern on a reticle before fabricating the reticle.

This prior art does not however achieve the demanded early detection of a data conversion error in a data conversion device. In other words, there is no issue of distinguishing that data conversion error from other fabrication defects. Therefore, the last prior art document also fails to disclose any specific means of solving the problem of the elongation of the reticle fabrication process and the cost increase both originated from such a data

conversion error.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide a reticle fabrication method which simplifies a reticle inspection process, improves the effective availability factors of devices needed for reticle fabrication, such as an EB write device and a reticle inspection device, shortens the time needed for reticle fabrication and cuts down the fabrication cost by detecting a defect, such as a data conversion error included in EB write data like a circuit pattern to be written on a reticle

A reticle fabrication method according to the first aspect of the invention comprises the steps of converting CAD (Computer Aided Design) data which is reticle design data to electron beam write data by means of a first data conversion device and to inspection data by means of a second data conversion device; comparing the electron beam write data with the inspection data in a data verification device to verify whether or not there is a data conversion error; fabricating a reticle using the electron beam write data after verifying that the electron beam write data is data correctly converted from the CAD data; and inspecting a quality of the reticle based on the inspection data.

A reticle fabrication method according to the second

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aspect of the invention comprises the steps of converting
first electron beam write data for writing a figure pattern
on a reticle based on reticle design data to second electron
beam write data by means of a first data conversion device
and to inspection data by means of a second data conversion
device; comparing the second electron beam write data with
the inspection data in a data verification device to verify
whether or not there is a data conversion error; fabricating
a reticle using the second electron beam write data after
verifying that the second electron beam write data is data
correctly converted from the first electron beam write data;
and inspecting a quality of the reticle based on the
inspection data.

A reticle fabrication method according to the third
aspect of the invention comprises the steps of converting
CAD (Computer Aided Design) data which is reticle design
data to electron beam write data by means of a first data
conversion device; comparing the electron beam write data
with the CAD data in a data verification device to verify
whether or not there is a data conversion error; fabricating
a reticle using the electron beam write data after verifying
that the electron beam write data is data correctly
converted from the CAD data; and inspecting a quality of the
reticle based on inspection data acquired by performing data
conversion of the electron beam write data by means of a

second data conversion device.

A reticle fabrication method according to the fourth aspect of the invention comprises the steps of converting CAD (Computer Aided Design) data which is reticle design
5   data to first electron beam write data and second electron beam write data by means of a first data conversion device and to first inspection data and second inspection data by means of a second data conversion device; comparing the first electron beam write data with the first inspection
10   data in a first data verification device to verify whether or not there is a data conversion error; comparing the second electron beam write data with the second inspection data in a second data verification device to verify whether or not there is a data conversion error; fabricating a
15   reticle using the first and second electron beam write data after verifying that the first and second electron beam write data are data correctly converted from the CAD data; and inspecting a quality of the reticle based on the first and second inspection data.

20   In those reticle fabrication methods, the data verification device can be constructed so as to verify whether or not there is a data conversion error by converting the electron beam write data and the inspection data to raster images to be used by an electron beam writing
25   device of a raster scan and stage continuous moving type and

comparing the raster images with each other.

The data verification device may verify whether or not there is a data conversion error by converting the electron beam write data and the inspection data to two-dimensional coordinate data and comparing the two-dimensional coordinate data with each other.

The reticle fabrication methods according to the invention use two data conversion devices to separately generate EB write data for writing a pattern on a reticle and inspection data for inspecting the reticle from CAD data or EB write data through data conversion and allow the data verification device to verify if there is a data conversion error contained in those data before EB writing to fabricate the reticle. This can reliably prevent fabrication of a defective reticle originated from a data conversion error. In case where a data conversion error is detected by the data verification device, the cause for the data conversion error occurred in each data conversion device can be found out instantaneously before reticle writing, it is possible to avoid writing a wasteful defective reticle, simplify the reticle inspection process and shorten the reticle fabrication period. This can lead to a noticeable reduction in reticle fabrication cost. Even in case where the reticle inspection device detects a defect on an EB-written and developed reticle, it is apparent that the cause for the

defect is not a data conversion error, thus making it

extremely easy to find out the cause for the defect.

Therefore, not only the cause for a defect, such as a data

conversion error, which occurs at an early stage of the

5   fabrication process, but also the cause for a defect which

is generated at a later stage of the fabrication process,

such as the EB writing process or the developing process,

can be found out easily at an early stage after the end of

the process where such a defect has occurred.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a flowchart illustrating a conventional

reticle fabrication method;

Fig. 2 is a flowchart illustrating a reticle

15   fabrication method according to a first embodiment of the

invention;

Fig. 3 is a flowchart illustrating the operation of the

reticle fabrication method according to the first embodiment

of the invention;

20   Fig. 4 is a flowchart showing one example of a data

verification scheme which is carried out by a data

verification device according to the invention;

Figs. 5A through 5D are diagrams showing examples of

data at individual sections in the data verification device

25   according to the invention;

Fig. 6 is a flowchart showing another example of the data verification scheme which is executed by the data verification device according to the invention;

Figs. 7A through 7D are diagrams showing examples of data at individual sections in the data verification device according to the invention;

Fig. 8 is a flowchart illustrating a reticle fabrication method according to a second embodiment of the invention;

Fig. 9 is a flowchart illustrating a reticle fabrication method according to a third embodiment of the invention; and

Fig. 10 is a flowchart illustrating a reticle fabrication method according to a fourth embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the invention will be described below with reference to the accompanying drawings. To avoid the redundant description, same reference numerals as given to the components of the first embodiment will be given to those components of the other embodiments which are identical to the corresponding components of the first embodiment throughout the specification.

Fig. 2 is a flowchart illustrating a reticle

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fabrication method according to the first embodiment of the invention. In the embodiment, CAD data 1 or reticle design data is input to a first data conversion device 2 and a second data conversion device 5. The first data conversion

5   device 2 performs a conversion process, such as rotation, magnification, reduction, expansion or contraction, on a figure pattern contained in the CAD data 1 and performs format conversion on the resultant data to thereby convert the CAD data 1 to EB write data 3. The second data

10 conversion device 5 performs a conversion process and format conversion on the figure pattern contained in the CAD data 1, which are similar to those done by the first data conversion device 2, thereby converting the CAD data 1 to inspection data 6. The EB write data 3 and the inspection

15 data 6 are input to a data verification device 8. The data verification device 8 verifies if the first data conversion device 2 and the second data conversion device 5 have performed data conversion correctly by comparing information on the figure patterns contained in the input EB write data

20 3 and inspection data 6 with each other. If the data verification device 8 verifies that the EB write data 3 is data correctly converted from the CAD data 1, the EB write data 3 is input to an EB write device 4 and is used as data for the EB write device 4 to write a figure pattern based on

25 the CAD data 1 on an unwritten reticle 9. The EB write

device 4 writes the figure pattern on the unwritten reticle 9 based on the input EB write data 3, thereby yielding a written reticle 10. The written reticle 10 is developed to become a developed reticle 11 which is in turn inspected by a reticle inspection device 7. The reticle inspection device 7, which is supplied with the inspection data 6, generates a reference image from the input inspection data 6. The reticle inspection device 7 also generates a to-be-inspected image from information obtained by scanning the surface of the developed reticle 11 with an ultraviolet laser and inspects if the figure pattern matching with the information of the CAD data 1 is correctly formed on the developed reticle 11 by comparing the to-be-inspected image with the reference image generated from the inspection data 6. The developed reticle 11 that has been detected as being free of a defect by the reticle inspection device 7 is decided as a good reticle and becomes an inspected reticle.

The operation of the reticle fabrication method according to the embodiment will be discussed below referring to the flowchart shown in Fig. 3. According to the embodiment, first, the first data conversion device 2 converts the CAD data 1 to the EB write data 3 (step S1). Then, the second data conversion device 5 converts the CAD data 1 to the inspection data 6 (step S2). Next, the data verification device 8 compares the EB write data 3 and the

inspection data 6 with each other (step S4). If the comparison has resulted in non-coincidence, it is decided that a data conversion error has occurred in either the first data conversion device 2 or the second data conversion device 5, i.e., data conversion is no good (step S9), and it is then verified whether a data conversion error has occurred in the first data conversion device 2 or the first data conversion device 2 which has converted the CAD data 1 to the EB write data 3 or the inspection data 6. If the EB write data 3 coincides with the inspection data 6 in step S4, on the other hand, the EB write data 3 is input to the EB write device 4 where a figure pattern in the EB write data 3 is written on an unwritten reticle 9 which in turn developed to be a developed reticle 11 (step S5). The developed reticle 11 is inspected by the reticle inspection device 7 (step S6). If the inspection result is successful (step S7), the developed reticle 11 can be decided as a good reticle (step S8), whereas if a defect is detected on the developed reticle 11 in step S7, it is decided that the defect has occurred in the EB writing process, i.e., writing is no good (step S10).

The following will discuss the details of the data verification device scheme executed by the data verification device 8. As shown in Fig. 2, the EB write data 3 and the inspection data 6 are input to the data verification device

8. Fig. 4 is a flowchart showing one example of the data

verification scheme which is carried out by the data

verification device 8. As shown in Fig. 4, the EB write

data 3 input to the data verification device 8 undergoes

5   data conversion to be a first raster image 22 in a first

raster image generating section 21 which generates a raster

image to be used in an electron beam writing device of a

raster scan and stage continuous moving type. Likewise, the

inspection data 6 input to the data verification device 8

10   undergoes data conversion to be a second raster image 24 in

a second raster image generating section 23. An image

comparison section 25 compares those first raster image 22

and second raster image 24 with each other and outputs an

image comparison result 26 which indicates whether those

15   image information coincide with each other or not.

Figs. 5A through 5D are diagrams showing examples of

data at individual sections in the data verification device

8 shown in Fig. 4. Because the EB write device 4 differs

from the reticle inspection device 7 in the device structure

20   and characteristic, the EB write data 3 and the inspection

data 6 which are data converted from the same CAD data and

including the same figure information but have figure

patterns of different expression forms are respectively

input to the EB write device 4 and the reticle inspection

25   device 7. Specifically, the EB write data 3 in Fig. 4 is

input to the data verification device 8 as data constructed by the combination of a plurality of rectangles, trapezoids and parallelepipeds as shown in Fig. 5A while the inspection data 6 in Fig. 4 is input to the data verification device 8

5   as data constructed by the combination of a single rectangle and a plurality of trapezoids as shown in Fig. 5C. To accurately compare the EB write data 3 and the inspection data 6, converted to figure patterns of different expression forms, with each other, therefore, those data are converted

10   to raster images of the same expression form in the data verification device 8. Fig. 5B shows an example of the first raster image 22 which is generated by data conversion of the EB write data 3 as shown in Fig. 5A in the first raster image generating section 21. In the first raster

15   image 22 shown in Fig. 5B, the hatched area is a figure area to be written on a reticle with an EB and portions indicated by marks "X" at the outer edge portions of the hatched area are those to be written in different tones with an EB. Fig. 5D shows an example of the second raster image 24 which is

20   generated by data conversion of the inspection data 6 as shown in Fig. 5C in the second raster image generating section 23. Because those first raster image 22 and second raster image 24 have the same expression form, they can be compared with each other easily by the image comparison

25   section 25.

Fig. 6 is a flowchart showing another example of the data verification scheme which is executed by the data verification device 8. The EB write data 3 input to the data verification device 8 undergoes data conversion in a

5   first figure synthesizing section 31, yielding a first set of polygonal figures (hereinafter called "first polygonal figure set") 32, as shown in Fig. 6. The inspection data 6 input to the data verification device 8 likewise undergoes data conversion in a second figure synthesizing section 33,

10   yielding a second set of polygonal figures (hereinafter called "second polygonal figure set") 34. A figure comparison section 35 compares those second first polygonal figure set 32 and second polygonal figure set 34 with each other and outputs a figure comparison result 36 which

15   indicates whether those figure information coincide with each other or not.

Figs. 7A through 7D are diagrams showing examples of data at individual sections in the data verification device 8 shown in Fig. 6. As in the example shown in Fig. 4 and

20   Figs. 5A-5D, the EB write data 3 in Fig. 6 is input to the data verification device 8 as data constructed by the combination of a plurality of rectangles, trapezoids and parallelepipeds as shown in Fig. 7A while the inspection data 6 in Fig. 6 is input to the data verification device 8

25   as data constructed by the combination of a single rectangle

and a plurality of trapezoids as shown in Fig. 7C. To accurately compare the EB write data 3 and the inspection data 6, converted to figure patterns of different expression forms, with each other, therefore, those data are converted to polygonal figure set information of the same expression form in the data verification device 8. Fig. 7B shows the first polygonal figure set 32 which is generated by data conversion of the EB write data 3 as shown in Fig. 7A in the first figure synthesizing section 31. Fig. 7D shows the second polygonal figure set 34 which is generated by data conversion of the inspection data 6 as shown in Fig. 7C in the second figure synthesizing section 33. As those first polygonal figure set 32 and second polygonal figure set 34 have the same expression form, a sequence of coordinates of the vertexes of one synthesized figure can be easily compared with a sequence of coordinates of the vertexes of the other synthesized figure by figure comparison section 35.

In the embodiment, as shown in Fig. 2, two different first data conversion devices, namely the first data conversion device 2 and the second data conversion device 5, perform data conversion of single CAD data 1 separately, thus generating the EB write data 3 and the inspection data 6 respectively. Even in case where a data conversion error has occurred in one first data conversion device, generating

an erroneous figure pattern, it is very unlikely that the same conversion error occurs in the same figure pattern in the other first data conversion device. It is therefore possible to easily detect if there is a data conversion

5   error by comparing the EB write data 3 and the inspection data 6, respectively generated through data conversion of the CAD data 1 in the first data conversion device 2 and the second data conversion device 5, with each other in the data verification device 8. Suppose that there are 100,000,000

10   figure patterns included in reticle design data needed to fabricate a single reticle and that the probability of occurrence of a data conversion error with respect to a single figure pattern in data conversion in a data conversion device is 10^{-8}. Under such an assumption, the

15   probability of occurrence of a data conversion error in data conversion of the CAD data 1 to the inspection data 6 with respect to the figure pattern which has generated a data conversion error in the data conversion of the CAD data 1 to the EB write data 3 is likewise 10^{-8}. Those data

20   conversions are carried out by the separate data conversion devices or the first data conversion device 2 and the second data conversion device 5, the probability, E, of occurrence of the same data conversion error with respect to a single figure pattern, i.e., the probability E that at least one

25   erroneous and improper figure pattern which is not

detectable by the data verification device 8 is present in figure patterns included in reticle design data for a single reticle can be computed simply as an independent event occurrence probability as given by the following equation 1.

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$$E = 1 - (1 - 10^{-8} \times 10^{-8})^{100000000} = 0.00000001 \quad (1)$$

It is apparent from the equation 1 that the probability E that at least one erroneous and improper figure pattern which is not detectable by the data verification device 8 is present in figure patterns included in reticle design data for a single reticle is negligibly small. According to the embodiment, therefore, it is possible to surely prevent fabrication of a defective reticle originated from a data conversion error by separately generating the EB write data 3 and the inspection data 6 from the CAD data 1 through data conversion in the first data conversion device 2 and the second data conversion device 5 and allowing the data verification device 8 to verify if there is a data conversion error included in those data before EB writing to fabricate a reticle. In case where a data conversion error is detected by the data verification device 8, it is possible to spontaneously find out the cause for the data conversion error in the data verification device 8 before writing a pattern on the reticle. This makes it possible to

avoid writing a pattern on a wasteful defective reticle,
simplify the reticle inspection process and shorten the
reticle fabrication period. Therefore, the reticle
fabrication cost can be reduced significantly. Even in case
5   where a defect on an EB-written and developed reticle 11 is
detected by the reticle inspection device 7, it is apparent
that the cause for this defect is not originated from a data
conversion error, so that it is extremely easy to find out
the cause for this defect. Therefore, not only the cause
10 for a defect, such as a data conversion error, which occurs
at an early stage of the fabrication process, but also the
cause for a defect which is generated at a later stage of
the fabrication process, such as the EB writing process or
the developing process, can be found out easily at an early
15 stage after the end of the process where such a defect has
occurred.

Fig. 8 is a flowchart illustrating a reticle
fabrication method according to the second embodiment of the
invention. In this embodiment, first, first EB write data
20 41 is input as reticle design data to the first data
conversion device 2 and a second data conversion device 5.
The first data conversion device 2 performs the conversion
process, such as rotation, magnification, reduction,
expansion or contraction, on a figure pattern contained in
25 the first EB write data 41 and performs format conversion on

the resultant data to thereby convert the first EB write
data 41 to second EB write data 43. The second data
conversion device 5 performs a conversion process and format
conversion on the figure pattern contained in the first EB
write data 41, which are similar to those done by the first
data conversion device 2, thereby converting the first EB
write data 41 to inspection data 6. The second EB write
data 43 and the inspection data 6 are input to a data
verification device 8. The data verification device 8
verifies if the first data conversion device 2 and the
second data conversion device 5 have performed data
conversion correctly by comparing information on the figure
patterns contained in the input second EB write data 43 and
inspection data 6 with each other, as per the first
embodiment. If the data verification device 8 verifies that
the second EB write data 43 is data correctly converted from
the first EB write data 41, the second EB write data 43 is
input to the EB write device 4 and is used as data for the
EB write device 4 to write a figure pattern based on the
first EB write data 41 on an unwritten reticle 9. The EB
write device 4 writes the figure pattern on the unwritten
reticle 9 based on the input second EB write data 43,
thereby yielding a written reticle 10. The written reticle
10 is developed to become a developed reticle 11 which is in
turn inspected by the reticle inspection device 7. The

reticle inspection device 7, which is supplied with the inspection data 6, generates a reference image from the input inspection data 6. The reticle inspection device 7 also generates a to-be-inspected image from information

5   obtained by scanning the surface of the developed reticle 11 with an ultraviolet laser and inspects if the figure pattern matching with the information of the first EB write data 41 is correctly formed on the developed reticle 11 by comparing the to-be-inspected image with the reference image generated

10   from the inspection data 6. The developed reticle 11 that has been detected as being free of a defect by the reticle inspection device 7 is decided as a good reticle and becomes an inspected reticle.

Fig. 9 is a flowchart illustrating a reticle

15   fabrication method according to the third embodiment of the invention. In the embodiment, CAD data 1 or reticle design data is input to the first data conversion device 2 and the second data conversion device 5. The first data conversion device 2 performs a conversion process, such as rotation,

20   magnification, reduction, expansion or contraction, on a figure pattern contained in the CAD data 1 and performs format conversion on the resultant data to thereby convert the CAD data 1 to EB write data 3. The data verification device 8 to which the CAD data 1 and the EB write data 3 are

25   input verifies if the first data conversion device 2 and the

CAD data 1 has been correctly converted to the EB write data 3 in the first data conversion device 2 by comparing figure information included in those pieces of data with each other, as per the first embodiment. If the data verification device 8 does not detect a data conversion error, the EB write data 3 is input to the EB write device 4 and the second data conversion device 5. The EB write device 4 having received the EB write data 3 writes the figure pattern on the unwritten reticle 9 based on the input EB write data 3, thereby yielding a written reticle 10. The written reticle 10 is developed to become a developed reticle 11 which is in turn inspected by the reticle inspection device 7. The second data conversion device 5 which has received the EB write data 3 performs a conversion process and format conversion on the EB write data 3, which are similar to those done by the first data conversion device 2, thereby converting the EB write data 3 to inspection data 6. The inspection data 6 is input to the reticle inspection device 7 which in turns verifies if the figure pattern matching with the information of the EB write data 3 is correctly formed on the developed reticle 11 by comparing a reference image generated from the inspection data 6 with a to-be-inspected image generated from information obtained by scanning the surface of the developed reticle 11 with an ultraviolet laser. The

developed reticle 11 that has been detected as being defectless by the reticle inspection device 7 is decided as a good reticle and becomes an inspected reticle.

A reticle fabrication method according to the fourth embodiment of the invention will be discussed below referring to the flowchart illustrated in Fig. 10. This embodiment is suitable for use in a reticle fabrication method which performs each of the EB writing process and developing process on a single reticle twice as done for a tritone mask and a phase shift mask which are used in super resolution techniques, such as OPC and phase shifting. In the embodiment, CAD data 1 or reticle design data is input to the first data conversion device 2 and the second data conversion device 5. The first data conversion device 2 performs a conversion process, such as rotation, magnification, reduction, expansion or contraction, on a figure pattern contained in the CAD data 1 and performs format conversion on the resultant data to thereby convert the CAD data 1 to first EB write data 51 and second EB write data 52. The second data conversion device 5 performs a conversion process and format conversion on the figure pattern contained in the CAD data 1, which are similar to those done by the first data conversion device 2, thereby converting the CAD data 1 to first inspection data 53 and second inspection data 54. The first EB write data 51 and

the first inspection data 53 are input to a first data verification device 56, and the second EB write data 52 and the second inspection data 54 are input to a second data verification device 58. The first data verification device 56 and the second data verification device 58 verify if the first data conversion device 2 and the second data conversion device 5 have performed data conversion correctly by respectively comparing information on the figure patterns included in the input first EB write data 51 and first inspection data 53 with each other and comparing information on the figure patterns included in the input second EB write data 52 and second inspection data 54 with each other. If the first data verification device 56 and the second data verification device 58 verify that both of the first EB write data 51 and the second EB write data 52 are data correctly converted from the CAD data 1, the first EB write data 51 is input to a first EB write device 55 and is used as data for the first EB write device 55 to write a figure pattern based on the CAD data 1 on an unwritten reticle 59. The first EB write device 55 writes the figure pattern on the unwritten reticle 59 based on the input first EB write data 51, thereby yielding a first written reticle 60. The first written reticle 60 is developed, with its unnecessary portion, such as the remaining Cr film, removed, and becomes a first developed reticle 61 on which a first pattern is

formed. Meanwhile, the second EB write data 52 is input to a second EB write device 57 and is used as data for the second EB write device 57 to write a figure pattern based on the CAD data 1 on the first developed reticle 61. The second EB write device 57 writes the figure pattern on the first developed reticle 61 coated with a photoresist, based on the input second EB write data 52, thereby yielding a second written reticle 62. The second written reticle 62 is developed, with its unnecessary portion, such as the remaining halftone film, removed and a part removed by etching of the glass layer of the surface of the quartz glass substrate, and becomes a second developed reticle 63 on which a second pattern is formed. The first inspection data 53 and second inspection data 54 are input to a reticle inspection device 64. The reticle inspection device 64 generates a reference image for reticle inspection from those first inspection data 53 and second inspection data 54 and compares this reference image with a to-be-inspected image generated from information obtained by scanning the surface of the second developed reticle 63 with an ultraviolet laser to verify if the figure pattern which matches with the information of the CAD data 1 is correctly formed on the second developed reticle 63 which has undergone pattern formation twice. The second developed reticle 63 that has been detected as defectless in the

inspection performed by the reticle inspection device 64 is decided as a good reticle and becomes an inspected reticle.

A reticle which is fabricated by the reticle fabrication method according to the invention is not limited to a reticle as a mask which is used in the photolithography technology that uses conventional short-wavelength light sources, such as g rays, i rays, KrF and ArF, but may be a mask which is used in the photolithography technology that uses light sources of an ultrashort-wavelength range, such as VUV and EUV, and the photolithography technology that uses other light sources than ultraviolet rays, such as X rays and EB.